

REMARKS

Claims 1- 67 remain in this application, Claims 1, 7, 10-12, 14-16, 25, 35, 46, 56, 57 and 61-66 being in independent form. Claims 1,7, 10-12, 14-16, 25, 35, 56, 57 and 61-66 have been amended of which Claims 7, 11, 12, 15, 16, 57, 64, and 66 have been rewritten in independent form and Claims 25 and 35 have been amended to correct an obvious formal error (with no change of scope.)

Applicant notes with appreciation the allowance of Claims 25-55 and the indication that Claims 7-9, 11-13, 15-24, 57, 58, 64, 66 and 67 would be allowable if rewritten so as not to depend from a rejected base claim. Since Claims 7, 11, 12, 15, 16, 57, 64, and 66 have been rewritten in independent form and Claims 8, 9, 13, 17-24, 58 and 67 depend from one of those claims. Claims 7-9, 11-13, 15-24, 57, 58, 64, 66 and 67 are now believed to be in condition for allowance.

Claims 1-6, 10, 14, 56, 59-63 and 65 were rejected under 35 U.S.C. § 102(b) as allegedly being anticipated by U.S. Patent No. 5,920,235 to *Beards*.

Reconsideration and withdrawal of the art rejections are respectfully requested in view of the present amendments and the following remarks.

The present invention is directed high frequency oscillator circuits and methods thereof, which can filter or attenuate flicker noise. As Applicant has observed phase noise is produced as a result of low frequency noise signal found in active elements used in the oscillator. This low frequency signal is modulated (up converted) by the fundamental signal tone, resulting in the spreading of the oscillator frequency energy beyond the intended target frequency. This low frequency noise signal source is often referred to as flicker noise (commonly referred to in the literature as $1/f$) in bipolar and Metal Oxide Semiconductor (MOS) transistors. The $1/f$ noise energy in bipolar transistors is known to be significantly less than that of MOS transistors. This is the reason why practically all low phase noise LC oscillators are built using bipolar transistors or even more esoteric transistors such as Gallium-Arsenide devices. The advancements in scaling of the

device features in semiconductor processing allow multi-gigahertz operating frequencies to be readily achievable. Unfortunately, the same scaling down of MOS transistors have the opposite effect on the $1/f$ noise characteristics. The smaller device geometries are, the higher the $1/f$ noise components, leading to higher phase noise on the final oscillator. The present invention solves this flicker noise problem by providing sufficient attenuation.

More specifically, Claims 1, 10, 14, 56, 61, 63 and 65 each recites an attenuating circuit or capacitor to attenuate the flicker noise. Claim 62 recites the step of attenuating the flicker noise. None of the art of record is seen to teach or suggest how to solve the flicker noise problem.

Beards is directed to a VCO formed with an IC cross-coupled negative resistance cell in which spurious oscillation caused by **package parasitics** is said to be greatly reduced or eliminated. (See column 2, lines 8-13). There is not even a mention of the terms flicker or $1/f$ in *Beards*. As such *Beards* could not possibly teach or suggest an attenuating circuit or capacitor to attenuate the flicker noise or the step of attenuating the flicker noise. Thus, Claims 1, 10, 14, 56, 61, 62, 63 and 65 are believed patentable over *Beard*.

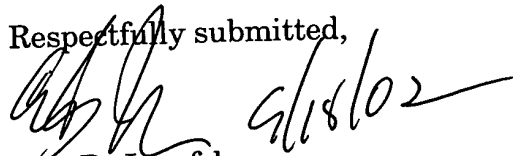
A review of the other art of record has failed to reveal anything which, in Applicant's opinion, would remedy the deficiencies of *Beard*, as references against the independent claims herein. Those claims are therefore believed patentable over the art of record.

The other claims in this application are each dependent from one or another of the independent claims discussed above and are therefore believed patentable for the same reasons. Since each dependent claim is also deemed to define an additional aspect of the invention, however, the individual reconsideration of the patentability of each on its own merits is respectfully requested.

CONCLUSION

In view of the foregoing amendments and remarks, Applicant respectfully requests favorable reconsideration and early passage to issue of the present application.

Respectfully submitted,

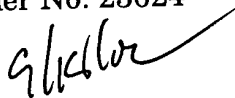


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UNMARKED CLAIMS

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1. (Amended) An oscillator having a fundamental frequency and having low phase noise comprising:

a frequency dependent amplifier;

a frequency dependent feedback device in communication with an output of said frequency dependent amplifier and an input of said frequency dependent amplifier; and

an attenuating device in communication with said frequency dependent amplifier to attenuate flicker noise.

2. The oscillator of claim 1 wherein said attenuating device has a characteristic such that the fundamental frequency is from approximately ten times to twenty times a high pass bandwidth of a combination of the frequency dependent amplifier and the attenuating device.

3. The oscillator of claim 1 wherein said amplifier amplifies an input by a predetermined gain factor, and wherein said frequency dependent feedback device comprises:

a frequency dependent gain determining in communication with said amplifier, wherein a maximum gain of said frequency dependent amplifier occurs at the fundamental frequency.

4. The oscillator of claim 3 wherein said amplifier comprises:

a pair of cross-coupled MOS transistors having a drain of each of said pair of cross-coupled MOS transistors being in communication with a gate of the other of said pair of cross-coupled MOS transistors and to a corresponding terminal of said frequency dependent gain determining impedance;

a first current source having a first terminal in communication with a source of a first one of said pair of cross-coupled MOS transistors and to a first terminal of said attenuating device; and

a second current source having a first terminal in communication with a source of a second one of said pair of cross-coupled MOS transistors and to a second terminal of said attenuating device.

5. The oscillator of claim 3 wherein said frequency dependent gain determining impedance comprises:

at least one inductor in communication with said amplifier and a first terminal of a voltage source; and

at least one capacitor in communication with said amplifier and a second terminal of the voltage source.

6. The oscillator of claim 4 wherein said attenuating device comprises a capacitor.

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7. (Amended) An oscillator having a fundamental frequency and having low phase noise comprising:

a frequency dependent amplifier;

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a frequency dependent feedback device in communication with an output of said frequency dependent amplifier and an input of said frequency dependent amplifier; and

an attenuating device in communication with said frequency dependent amplifier to attenuate noise signals having a frequency much less than the fundamental frequency,

wherein said amplifier amplifies an input by a predetermined gain factor, and wherein said frequency dependent feedback device comprises:

a frequency dependent gain determining in communication with said amplifier, wherein a maximum gain of said frequency dependent amplifier occurs at the fundamental frequency;

a second attenuating device, and

wherein said amplifier comprises:

a first pair of cross-coupled MOS transistors of a first conductivity type having a drain of each of said first pair of cross-coupled MOS transistors being in communication with a gate of the other of said first pair of cross-coupled MOS transistors and to a corresponding terminal of said frequency dependent gain determining impedance;

a first current source in communication with a source of one of said first pair of cross-coupled MOS transistors of the first conductivity type and with a first terminal of said attenuating device;

a second current source in communication with a source of a second one of said first pair of cross-coupled MOS transistors of the first conductivity type and with a second terminal of said attenuating device;

a second pair of cross-coupled MOS transistors of a second conductivity type whereby a drain of each of said second pair of cross-coupled MOS transistors is connected to a gate of the other of said second pair of cross-coupled MOS transistors and to one terminal of said frequency dependent gain determining impedance;

a third current source in communication with a source of one of said second pair of cross-coupled MOS transistors and with a first terminal of said second attenuating device; and

a fourth current source in communication with a source of the other of said second pair of cross-coupled MOS transistors of the second conductivity type and with a fourth second terminal of said second attenuating device.

8. The oscillator of claim 7 wherein said attenuating device comprises a first capacitor.

9. The oscillator of claim 7 wherein said second attenuating device comprises a second capacitor.

sub (B)
10. (Amended) An LC oscillator having a fundamental frequency and having low phase noise comprising:

a frequency dependent amplifier comprising:

a pair of cross-coupled MOS transistors of a first conductivity type, a drain of each of said pair of cross-coupled MOS being in communication with a gate of the other one of said pair of cross-coupled MOS transistors,

a first current source in communication with a source of one of said pair of cross-coupled MOS transistors, and

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a second current source in communication with a source of another of said pair of cross-coupled MOS transistors;

a frequency dependent gain determining circuit comprising

a first inductor in communication with the drain of said one of said pair of cross-coupled MOS transistors and a first terminal of a voltage source,

a second inductor in communication with the drain of the other of said pair of cross-coupled MOS transistors and the first terminal of the voltage source,

a first capacitor in communication with the drain of said one of said pair of cross-coupled MOS transistors and a second terminal of the voltage source, and

a second capacitor in communication with the drain of the other of said pair of cross-coupled MOS transistors and the second terminal of the voltage source; and

an attenuating circuit in communication with said frequency dependent amplifier to reduce flicker noise, wherein said attenuating circuit comprises a third capacitor in communication with said first and second current sources.

11. (Amended) An LC oscillator having a fundamental frequency and having low phase noise comprising:

a frequency dependent amplifier comprising:

a pair of cross-coupled MOS transistors of a first conductivity type, a drain of each of said pair of cross-coupled MOS being in communication with a gate of the other one of said pair of cross-coupled MOS transistors,

a first current source in communication with a source of one of said pair of cross-coupled MOS transistors, and

a second current source in communication with a source of another of said pair of cross-coupled MOS transistors;

a frequency dependent gain determining circuit comprising

a first inductor in communication with the drain of said one of said pair of cross-coupled MOS transistors and a first terminal of a voltage source,

a second inductor in communication with the drain of the other of said pair of cross-coupled MOS transistors and the first terminal of the voltage source,

a first capacitor in communication with the drain of said one of said pair of cross-coupled MOS transistors and a second terminal of the voltage source, and

a second capacitor in communication with the drain of the other of said pair of cross-coupled MOS transistors and the second terminal of the voltage source; and

an attenuating circuit in communication with said frequency dependent amplifier to reduce the gain of signals having frequencies less than the fundamental

frequency to decrease the phase noise, wherein said attenuating circuit comprises a third capacitor in communication with said first and second current sources,

wherein said attenuating device has a characteristic such that the fundamental frequency is from approximately ten times to twenty times a high pass bandwidth of a combination of said frequency dependent amplifier and said attenuating device.

12. (Amended) An LC oscillator having a fundamental frequency and having low phase noise comprising:

a frequency dependent amplifier comprising:

a pair of cross-coupled MOS transistors of a first conductivity type, a drain of each of said pair of cross-coupled MOS being in communication with a gate of the other one of said pair of cross-coupled MOS transistors,

a first current source in communication with a source of one of said pair of cross-coupled MOS transistors, and

a second current source in communication with a source of another of said pair of cross-coupled MOS transistors;

a frequency dependent gain determining circuit comprising

a first inductor in communication with the drain of said one of said pair of cross-coupled MOS transistors and a first terminal of a voltage source,

a second inductor in communication with the drain of the other of said pair of cross-coupled MOS transistors and the first terminal of the voltage source,

a first capacitor in communication with the drain of said one of said pair of cross-coupled MOS transistors and a second terminal of the voltage source, and

a second capacitor in communication with the drain of the other of said pair of cross-coupled MOS transistors and the second terminal of the voltage source; and

an attenuating circuit in communication with said frequency dependent amplifier to reduce the gain of signals having frequencies less than the fundamental frequency to decrease the phase noise, wherein said attenuating circuit comprises a third capacitor in communication with said first and second current sources,

wherein said amplifier further comprises:

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a second pair of cross-coupled MOS transistors of a second conductivity type each having a drain connected to a gate of the other of second pair of cross-coupled MOS,

a third current source in communication with a source of one of said second pair of cross-coupled MOS transistors, and

a fourth current source in communication with a source of the other of said second pair of cross-coupled MOS.

13. The LC oscillator of claim 12 wherein said attenuating circuit further comprises a fourth capacitor in communication with said third and fourth current sources.

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14. (Amended) An RF communication device comprising:

an oscillator having a fundamental frequency and having low phase noise comprising:

a frequency dependent amplifier;

a frequency dependent feedback device in communication with an output of said frequency dependent amplifier and an input of said frequency dependent amplifier; and

an attenuating device in communication with said frequency dependent amplifier to attenuate flicker noise signals having a frequency much less than the fundamental frequency.

15. (Amended) An RF communication device comprising:

an oscillator having a fundamental frequency and having low phase noise comprising:

a frequency dependent amplifier;

a frequency dependent feedback device in communication with an output of said frequency dependent amplifier and an input of said frequency dependent amplifier; and

an attenuating device in communication with said frequency dependent amplifier to attenuate noise signals having a frequency much less than the fundamental frequency,

wherein said attenuating device has a characteristic such that the fundamental frequency is from approximately ten times to twenty times a high pass bandwidth of a combination of the frequency dependent amplifier and the attenuating device.

16. (Amended) An RF communication device comprising:

an oscillator having a fundamental frequency and having low phase noise comprising:

a frequency dependent amplifier;

a frequency dependent feedback device in communication with an output of said frequency dependent amplifier and an input of said frequency dependent amplifier; and

an attenuating device in communication with said frequency dependent amplifier to attenuate noise signals having a frequency much less than the fundamental frequency,

wherein said device comprises an RF transmitter and said oscillator comprises a carrier oscillator to provide a carrier frequency signal for said RF transmitter.

17. The RF communication device of claim 15 wherein said device comprises an RF receiver and said oscillator comprises a local oscillator to demodulate a carrier frequency signal received by said RF receiver.

18. The RF communication device of claim 15 wherein said amplifier amplifies an input signal by a predetermined gain factor, and wherein said frequency dependent feedback device comprises:

a frequency dependent gain determining impedance in communication with said amplifier, wherein a maximum gain of said frequency dependent amplifier occurs at the fundamental frequency.

19. The RF communication device of claim 18 wherein said amplifier comprises:

a pair of cross-coupled MOS transistors having a drain of each of said pair of cross-coupled MOS transistors being in communication with a gate of the other of said pair of cross-coupled MOS transistors and to a corresponding terminal of said frequency dependent gain determining impedance;

a first current source having a first terminal in communication with a source of a first one of said pair of cross-coupled MOS transistors and with a first terminal of said attenuating device; and

a second current source having a first terminal in communication with a source of a second one of said pair of cross-coupled MOS transistors and with a second terminal of said attenuating device.

20. The RF communication device of claim 18 wherein said frequency dependent gain determining impedance comprises:

at least one inductor in communication with said amplifier and a first terminal of a voltage source; and

at least one capacitor in communication with said amplifier and a second terminal of the voltage source.

21. The RF communication device of claim 19 wherein said attenuating device comprises a capacitor.

22. The RF communication device of claim 19 further comprising a second attenuating device, and wherein said amplifier comprises:

a first pair of cross-coupled MOS transistors of a first conductivity type having a drain of each of said first pair of cross-coupled MOS transistors being in communication with a gate of the other of said first pair of cross-coupled MOS transistors and to a corresponding terminal of said frequency dependent gain determining impedance;

a first current source in communication with a source of one of said first pair of cross-coupled MOS transistors of the first conductivity type and with a first terminal of said attenuating device;

a second current source in communication with a source of a second one of said first pair of cross-coupled MOS transistors of the first conductivity type and with a second terminal of said attenuating device;

a second pair of cross-coupled MOS transistors of a second conductivity type wherein a drain of each of said second pair of cross-coupled MOS transistors is connected to a gate of the other of said second pair of cross-coupled MOS transistors and to one terminal of said frequency dependent gain determining impedance;

a third current source in communication with a source of one of said second pair of cross-coupled MOS transistors and with a first terminal of said second attenuating device; and

a fourth current source in communication with a source of the other of said second pair of cross-coupled MOS transistors of the second conductivity type and to a fourth second terminal of said second attenuating device.

23. The RF communication device of claim 22 wherein said attenuating device comprises a first capacitor.

24. The RF communication device of claim 22 wherein said second attenuating device comprises a second capacitor .

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25. (Amended) A frequency transforming apparatus having low phase noise comprising:

a first oscillator having a first fundamental frequency comprising:

a first frequency dependent amplifier;

a first frequency dependent feedback device in communication with an output of said first frequency dependent amplifier and an input of said first frequency dependent amplifier; and

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a first attenuating device in communication with said first frequency dependent amplifier to attenuate noise signals having a frequency much less than the first fundamental frequency;

a second oscillator having a second fundamental frequency comprising:

a second frequency dependent amplifier;

a second frequency dependent feedback device in communication with an output of said second frequency dependent amplifier and an input of said second frequency dependent amplifier; and

a second attenuating device in communication with said second frequency dependent amplifier to attenuate noise signals having a frequency much less than the second fundamental frequency; and

a frequency dependent coupling circuit having a third fundamental frequency in communication with an output of the first oscillator and an input of the second oscillator, said frequency dependent coupling circuit comprising:

a third frequency amplifier, and

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a third attenuating device in communication with said third frequency dependent amplifier to attenuate noise signals having frequencies much less than the third fundamental frequency.

26. The frequency transforming apparatus of claim 25 wherein said first and second attenuating devices each have a respective characteristic such that the first and second fundamental frequencies are from approximately ten times to twenty times a high pass bandwidth of a respective combination of said first and second frequency dependent amplifiers, said first and second attenuating devices and said third frequency dependent amplifier and said third attenuating device.

27. The frequency transforming apparatus of claim 25 wherein said first, second and second frequency dependent amplifiers each amplifies an input by a respective predetermined gain factor,

wherein said first frequency dependent feedback device comprises:

a first frequency dependent gain determining impedance in communication with said first amplifier, wherein a first maximum gain of said first frequency dependent amplifier occurs at the first fundamental frequency, and

wherein said second frequency dependent feedback device comprises:

a second frequency dependent gain determining impedance in communication with said second amplifier, wherein a second maximum gain of said second frequency dependent amplifier occurs at the second fundamental frequency.

28. The frequency transforming apparatus of claim 27

wherein said first amplifier comprises:

a first pair of cross-coupled MOS transistors having a drain of each of said first pair of cross-coupled MOS transistors being in communication with a gate of the other of said first pair of cross-coupled MOS transistors and to a

corresponding terminal of said first frequency dependent gain determining impedance;

a first current source having a first terminal in communication with a source of a first one of said first pair of cross-coupled MOS transistors and with a first terminal of said first attenuating device; and

a second current source having a first terminal in communication with a source of a second one of said first pair of cross-coupled MOS transistors and with a second terminal of said first attenuating device, and

wherein said second amplifier comprises:

a second pair of cross-coupled MOS transistors having a drain of each of said second pair of cross-coupled MOS transistors being in communication with a gate of the other of said second pair of cross-coupled MOS transistors and to a corresponding terminal of said second frequency dependent gain determining impedance;

a third current source having a first terminal in communication with a source of a first one of said second pair of cross-coupled MOS transistors and with a first terminal of said second attenuating device; and

a fourth current source having a first terminal in communication with a source of a second one of said second pair of cross-coupled MOS transistors and with a second terminal of said second attenuating device.

29. The frequency transforming apparatus of claim 27 wherein each of said first and second frequency dependent gain determining impedance comprises:

at least one inductor in communication with a respective one of said first and second amplifiers and a first terminal of a voltage source; and

at least one capacitor in communication with said a respective one of said first and second amplifiers and a second terminal of the voltage source.

30. The frequency transforming apparatus of claim 29 wherein the first, second and third attenuating devices each comprises a capacitor.

31. The frequency transforming apparatus of claim 27 wherein said first and second oscillators each comprise another attenuating device,

wherein said first and second amplifiers each comprises:

a first pair of cross-coupled MOS transistors of a first conductivity type having a drain of each of said first pair of cross-coupled MOS transistors being in communication with a gate of the other of said first pair of cross-coupled MOS transistors and to a corresponding terminal of a respective one of said frequency dependent gain determining impedances;

a first current source in communication with a source of one of said first pair of cross-coupled MOS transistors of the first conductivity type and with a first terminal of a respective one of said attenuating devices;

a second current source in communication with a source of a second one of said first pair of cross-coupled MOS transistors of the first conductivity type and with a second terminal of a respective one of said attenuating devices;

a second pair of cross-coupled MOS transistors of a second conductivity type wherein a drain of each of said second pair of cross-coupled MOS transistors is connected to a gate of the other of said second pair of cross-coupled MOS transistors and to one terminal of a respective one of said frequency dependent gain determining impedances;

a third current source in communication with a source of one of said second pair of cross-coupled MOS transistors and with a first terminal of a respective one of said other attenuating devices; and

a fourth current source in communication with a source of the other of said second pair of cross-coupled MOS transistors of the second conductivity type and to a fourth second terminal of a respective one of said other attenuating device.

32. The frequency transforming apparatus of claim 31 wherein said attenuating device and said other attenuating device each comprises a first capacitor.

33. The frequency transforming apparatus of claim 32 wherein said attenuating device and said other attenuating device each comprises a second capacitor.

34. The frequency transforming apparatus of claim 25 wherein said frequency dependent coupling circuit is selected from the group of coupling circuits consisting of phase shifters, frequency mixers, frequency shifters, modulators, and demodulators.

35. (Amended) A multiple frequency oscillation circuit having low phase noise, comprising:

a first oscillator having a first fundamental frequency comprising:

a first frequency dependent amplifier;

a first frequency dependent feedback device in communication with an output of said first frequency dependent amplifier and an input of said first frequency dependent amplifier; and

a first attenuating device in communication with said first frequency dependent amplifier to attenuate noise signals having a frequency much less than the first fundamental frequency;

a second oscillator having a second fundamental frequency comprising:

a second frequency dependent amplifier;

a second frequency dependent feedback device in communication with an output of said second frequency dependent amplifier and an input of said second frequency dependent amplifier; and

a second attenuating device in communication with said second frequency dependent amplifier to attenuate noise signals having a frequency much less than the second fundamental frequency; and

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a frequency dependent coupling circuit having a third fundamental frequency in communication with an output of the first oscillator and an input of the second oscillator, said frequency dependent coupling circuit comprising:

a third frequency amplifier, and

a third attenuating device in communication with said third frequency dependent amplifier to attenuate noise signals having frequencies much less than the third fundamental frequency.

36. The multiple frequency oscillation circuit of claim 35 said first and second attenuating devices each has a respective characteristic such that the first and second fundamental frequencies are from approximately ten times to twenty times a high pass bandwidth of a respective combination of said first and second frequency dependent amplifiers, said first and second attenuating devices and said third frequency dependent amplifier and said third attenuating device.

37. The multiple frequency oscillation circuit of claim 35 wherein said first, second and second frequency dependent amplifiers each amplifies an input by a respective predetermined gain factor,

wherein said first frequency dependent feedback device comprises:

a first frequency dependent gain determining impedance in communication with said first amplifier, wherein a first maximum gain of said first frequency dependent amplifier occurs at the first fundamental frequency, and

wherein said second frequency dependent feedback device comprises:

a second frequency dependent gain determining impedance in communication with said second amplifier, wherein a second maximum gain of said second frequency dependent amplifier occurs at the second fundamental frequency

38. The multiple frequency oscillation circuit of claim 37 wherein said first amplifier comprises:

a first pair of cross-coupled MOS transistors having a drain of each of said first pair of cross-coupled MOS transistors being in communication with a gate of the other of said first pair of cross-coupled MOS transistors and to a corresponding terminal of said first frequency dependent gain determining impedance;

a first current source having a first terminal in communication with a source of a first one of said first pair of cross-coupled MOS transistors and with a first terminal of said first attenuating device; and

a second current source having a first terminal in communication with a source of a second one of said first pair of cross-coupled MOS transistors and with a second terminal of said first attenuating device, and

wherein said second amplifier comprises:

a second pair of cross-coupled MOS transistors having a drain of each of said second pair of cross-coupled MOS transistors being in communication with a gate of the other of said second pair of cross-coupled MOS transistors and to a corresponding terminal of said second frequency dependent gain determining impedance;

a third current source having a first terminal in communication with a source of a first one of said second pair of cross-coupled MOS transistors and with a first terminal of said second attenuating device; and

a fourth current source having a first terminal in communication with a source of a second one of said second pair of cross-coupled MOS transistors and with a second terminal of said second attenuating device.

39. The multiple frequency oscillation circuit of claim 37 wherein each of said first and second frequency dependent gain determining impedances comprises:

at least one inductor in communication with a respective one of said first and second amplifiers and a first terminal of a voltage source; and

at least one capacitor in communication with said a respective one of said first and second amplifiers and a second terminal of the voltage source.

40. The multiple frequency oscillation circuit of claim 39 wherein said first, second and third attenuating devices each comprises a capacitor.

41. The multiple frequency oscillation circuit of claim 37 wherein said first and second oscillators each comprises another attenuating device,

wherein said first and second amplifiers each comprises:

a first pair of cross-coupled MOS transistors of a first conductivity type having a drain of each of said first pair of cross-coupled MOS transistors being in communication with a gate of the other of said first pair of cross-coupled MOS transistors and to a corresponding terminal of a respective one of said frequency dependent gain determining impedances;

a first current source in communication with a source of one of said first pair of cross-coupled MOS transistors of the first conductivity type and with a first terminal of a respective one of said attenuating devices;

a second current source in communication with a source of a second one of said first pair of cross-coupled MOS transistors of the first conductivity type and with a second terminal of a respective one of said attenuating devices;

a second pair of cross-coupled MOS transistors of a second conductivity type whereby a drain of each of said second pair of cross-coupled MOS transistors is connected to a gate of the other of said second pair of cross-coupled MOS transistors and to one terminal of a respective one of said frequency dependent gain determining impedances;

a third current source in communication with a source of one of said second pair of cross-coupled MOS transistors and with a first terminal of a respective one of said other attenuating devices; and

a fourth current source in communication with a source of the other of said second pair of cross-coupled MOS transistors of the second conductivity type and to a fourth second terminal of a respective one of said other attenuating device.

42. The multiple frequency oscillation circuit of claim 41 said attenuating device and said other attenuating device each comprises a first capacitor.

43. The multiple frequency oscillation circuit of claim 42 wherein said attenuating device and said other attenuating device each comprises a second capacitor.

44. The multiple frequency oscillation circuit of claim 35 wherein said frequency dependent coupling circuit generate phase shifts of the first and second fundamental frequencies.

45. The multiple frequency oscillation circuit of claim 44 wherein the first and second fundamental frequencies 90° out of phase.

46. A quadrature oscillator circuit having low phase noise, comprising:

~~a first oscillator having a first fundamental frequency comprising:~~

a first frequency dependent amplifier device;

a first frequency dependent feedback device in communication with an output of said first frequency dependent amplifier and an input of said first frequency dependent amplifier to feed a portion of an amplified signal having the

first fundamental frequency to an input of said first frequency dependent amplifier; and

a first attenuating device in communication with said first frequency dependent gain amplifier for reducing the gain of said first frequency dependent amplifier for signals having frequencies much less than the first fundamental frequency to decrease said phase noise; and

a first frequency dependent coupling circuit having a second fundamental frequency having an input in communication with the output of the first frequency dependent amplifier, said first frequency dependent coupling circuit comprising:

a second frequency dependent amplifier, and

a second attenuating device in communication with said second frequency dependent amplifier for reducing the gain of said frequency dependent amplifier for signals having frequencies much less than said second fundamental frequency to decrease said phase noise;

a second oscillator to generate a second fundamental signal having a third fundamental frequency having low phase noise, in communication with an output of the second frequency dependent amplifier, and said second oscillator comprising:

a third frequency dependent amplifier;

a third frequency dependent feedback device in communication with an output of said third frequency dependent amplifier and an input of said third frequency dependent amplifier to feed a portion of an amplified signal having the third fundamental frequency to an input of said third frequency dependent amplifier; and

a third attenuating device in communication with the third frequency dependent amplifier for reducing the gain of said third frequency dependent amplifier for signals having frequencies much less than the third fundamental frequency to decrease the phase noise; and

a second frequency dependent coupling circuit having a fourth fundamental frequency having an input in communication with the output of said third frequency dependent amplifier and the input of said first frequency dependent such that a phase of the third fundamental frequency is reversed relative to a phase of the first fundamental frequency, and comprising:

a fourth frequency dependent amplifier, and

a fourth attenuating device in communication with said second frequency dependent amplifier for reducing the gain of said fourth frequency dependent amplifier for signals having frequencies much less than said fourth fundamental frequency to decrease the phase noise.

47. The quadrature oscillator circuit of claim 46 wherein said first, second, third and fourth attenuating devices each has a characteristic such that the first, second, third and fourth fundamental frequencies are each from approximately ten times to twenty times a high pass bandwidth of a respective combination of said first frequency dependent amplifier and said first attenuating device and of said third frequency dependent amplifier and said third attenuating device.

48. The quadrature oscillator circuit of claim 46 wherein said first, second, third and fourth frequency dependent amplifiers each amplify an input signal by respective predetermined gain factors, wherein said first, second, third and fourth frequency dependent each comprises:

a frequency dependent gain determining impedance in communication with a corresponding one of said first, second, third and fourth frequency dependent amplifiers, wherein the maximum gain of each of said corresponding one of said first, second, third and fourth frequency dependent amplifiers, occurs at a respective one of the first, second, third and fourth fundamental frequencies.

49. The quadrature oscillator circuit of claim 48 wherein each of said first, second, third and fourth amplifiers comprises:

a pair of cross-coupled MOS transistors whereby a drain of each of pair of cross-coupled MOS transistors is in communication with a gate of another one of said pair of cross-coupled MOS transistors and said frequency dependent gain determining impedance;

a first current source in communication with a source of one of said pair of cross-coupled MOS transistors and to a first terminal of a voltage source and to a first terminal of a respective one of said first, second, third and fourth attenuating devices; and

a second current source in communication with a source of the other one of said pair of cross-coupled MOS transistors and to a first terminal of a respective one of said first, second, third and fourth attenuating devices.

50. The quadrature oscillator circuit of claim 48 wherein each of said first, second, third and fourth frequency dependent gain determining impedances comprises:

at least one inductor in communication with of a respective one of said first, second, third and fourth amplifiers and a second terminal of the voltage source; and

at least one capacitor in communication with of a respective one of said first, second, third and fourth amplifiers and a third terminal of the voltage source.

51. The quadrature oscillator circuit of claim 50 wherein each of said first, second, third and fourth attenuating devices comprises a capacitor.

52. The quadrature oscillator circuit of claim 48 wherein each of said first, second, third and fourth amplifiers comprises:

an additional attenuating device;

a first cross-coupled pair of MOS transistors of the first conductivity type having a drain of each of said first cross-coupled pair of MOS transistors in communication with a gate of the other of said first cross-coupled pair of MOS transistors and to a terminal of a respective one of said first, second, third and fourth frequency dependent gain determining impedances;

a first current source in communication with a source of one of said first cross-coupled pair of MOS transistors and to a first terminal of a respective one of said first, second, third and fourth attenuating devices;

a second current source in communication with a source of the other said first cross-coupled pair of MOS transistors and to a terminal of a respective one of said first, second, third and fourth attenuating devices;

a second cross-coupled pair of MOS transistors of the second conductivity type have a drain of each of second cross-coupled pair of MOS transistors in communication with a gate of the other of second cross-coupled pair of MOS transistors and to the first terminal of a respective one of said first, second, third and fourth attenuating devices;

a third current source in communication with a source of one of said second cross-coupled pair of MOS transistors and to a first terminal of said additional attenuating device; and

a fourth current source in communication with a source of the other of said second cross-coupled pair of MOS transistors and to a second terminal of said additional attenuating device.

53. The quadrature oscillator circuit of claim 52 wherein said first, second, third and fourth attenuating devices each comprises a first capacitor.

54. The quadrature oscillator circuit of claim 52 said additional attenuating device comprises a second capacitor.

55. The quadrature oscillator circuit of claim 46 wherein said second frequency dependent coupling circuit generates a phase shift of the second fundamental frequency.

56. (Amended) A differential amplifier possessing low phase noise, comprising:

- a first transistor having a first terminal to receive an in-phase signal, and a second terminal to provide an out-of-phase signal;
- a second transistor having a first terminal to receive the out-of-phase signal, and a second terminal to provide the in-phase signal;
- a first biasing source in communication with a third terminal of said first transistor and a first terminal of a voltage source;
- a second biasing source in communication with a third terminal of the second transistor and the first terminal of the voltage source; and
- a capacitor in communication with the third terminal of said first transistor and the third terminal of said second transistor, said capacitor decreases gain of said differential amplifier flicker noise components from the in-phase and the out-of-phase signals.

57. (Amended) A differential amplifier possessing low phase noise, comprising:

- a first transistor having a first terminal to receive an in-phase signal, and a second terminal to provide an out-of-phase signal;
- a second transistor having a first terminal to receive the out-of-phase signal, and a second terminal to provide the in-phase signal;
- a first biasing source in communication with a third terminal of said first transistor and a first terminal of a voltage source;
- a second biasing source in communication with a third terminal of the second transistor and the first terminal of the voltage source; and

a capacitor in communication with the third terminal of said first transistor and the third terminal of said second transistor, said capacitor decreases gain of said differential amplifier at low frequencies to eliminate phase noise components from the in-phase and the out-of-phase signals,

wherein a high pass bandwidth of said differential amplifier is determined as follows:

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$$BW = \frac{g_m}{2\pi Cc}$$

where:

BW is the high pass bandwidth,

g_m is the transconductance of said first and second transistors as measured at the third terminals, and

Cc is the value of said capacitor,

wherein the high pass bandwidth is less than a cutoff frequency of a circuit employing said differential amplifier.

58. The differential amplifier of claim 57 wherein the cutoff frequency of the circuit containing said differential amplifier is from approximately 10 times to approximately 20 times the high pass bandwidth of said differential amplifier.

59. The differential amplifier of claim 56 wherein said first and second transistors are selected from the group of transistors consisting of NMOS transistors, PMOS transistors, and bipolar transistors.

60. The differential amplifier of claim 56 wherein said first and second biasing sources are selected from the group of biasing sources consisting of current sources and resistors.

61. (Amended) An oscillator having a fundamental frequency and having low phase noise comprising:

frequency dependent amplifier means for amplifying a signal;

frequency dependent feedback means for providing feedback to said frequency dependent amplifying means; and

attenuating means for attenuating flicker noise signals.

62. (Amended) A method of generating a signal having a fundamental frequency with low noise comprising the steps of:

(a) amplifying a signal;

(b) providing feedback to step (a); and

(c) attenuating flicker noise the signal in step (a).

63. (Amended) An LC oscillator having a fundamental frequency and having low phase noise comprising:

a frequency dependent amplifier comprising:

a pair of cross-coupled MOS transistors of a first conductivity type, a drain of each of said pair of cross-coupled MOS being in communication with a gate of the other one of said pair of cross-coupled MOS transistors,

a first current source in communication with a source of one of said pair of cross-coupled MOS transistors, wherein said first current source comprises a first programmable resistance, and

a second current source in communication with a source of another of said pair of cross-coupled MOS transistors, wherein said second current source comprises a second programmable resistance;

a capacitance in communication with a the source of the one of said pair of cross-coupled MOS transistors and the source of another of said pair of cross-coupled MOS transistors to filter flicker noise;

a frequency dependent gain determining circuit comprising

a first inductor in communication with the drain of said one of said pair of cross-coupled MOS transistors and a first terminal of a voltage source,

a second inductor in communication with the drain of the other of said pair of cross-coupled MOS transistors and the first terminal of the voltage source,

a first capacitor in communication with the drain of said one of said of said pair of cross-coupled MOS transistors and a second terminal of the voltage source, and

a second capacitor in communication with the drain of the other of said pair of cross-coupled MOS transistors and the second terminal of the voltage source.

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64. (Amended) An LC oscillator having a fundamental frequency and having low phase noise comprising:

a frequency dependent amplifier comprising:

a pair of cross-coupled MOS transistors of a first conductivity type, a drain of each of said pair of cross-coupled MOS being in communication with a gate of the other one of said pair of cross-coupled MOS transistors,

a first current source in communication with a source of one of said pair of cross-coupled MOS transistors, wherein said first current source comprises a first programmable resistance, and

a second current source in communication with a source of another of said pair of cross-coupled MOS transistors, wherein said second current source comprises a second programmable resistance;

a frequency dependent gain determining circuit comprising

a first inductor in communication with the drain of said one of said pair of cross-coupled MOS transistors and a first terminal of a voltage source,

a second inductor in communication with the drain of the other of said pair of cross-coupled MOS transistors and the first terminal of the voltage source,

a first capacitor in communication with the drain of said one of said of said pair of cross-coupled MOS transistors and a second terminal of the voltage source, and

a second capacitor in communication with the drain of the other of said pair of cross-coupled MOS transistors and the second terminal of the voltage source,

wherein the first current source comprises a first inductor in communication with said first programmable resistance, and wherein the second current source comprises a second inductor in communication with said second programmable resistance.

65. (Amended) An LC oscillator having a fundamental frequency and having low phase noise comprising:

a frequency dependent amplifier comprising:

a pair of cross-coupled MOS transistors of a first conductivity type, a drain of each of said pair of cross-coupled MOS being in communication with a gate of the other one of said pair of cross-coupled MOS transistors,

a first current source in communication with a source of one of said pair of cross-coupled MOS transistors, wherein said first current source comprises a first programmable inductance, and

a second current source in communication with a source of another of said pair of cross-coupled MOS transistors, wherein said second current source comprises a second programmable inductance;

a capacitance in communication with a the source of the one of said pair of cross-coupled MOS transistors and the source of another of said pair of cross-coupled MOS transistors to filter flicker noise;

a frequency dependent gain determining circuit comprising

a first inductor in communication with the drain of said one of said pair of cross-coupled MOS transistors and a first terminal of a voltage source,

a second inductor in communication with the drain of the other of said pair of cross-coupled MOS transistors and the first terminal of the voltage source,

a first capacitor in communication with the drain of said one of said of said pair of cross-coupled MOS transistors and a second terminal of the voltage source, and

a second capacitor in communication with the drain of the other of said pair of cross-coupled MOS transistors and the second terminal of the voltage source.

66. (Amended) An LC oscillator having a fundamental frequency and having low phase noise comprising:

a frequency dependent amplifier comprising:

a pair of cross-coupled MOS transistors of a first conductivity type, a drain of each of said pair of cross-coupled MOS being in communication with a gate of the other one of said pair of cross-coupled MOS transistors,

a first current source in communication with a source of one of said pair of cross-coupled MOS transistors, and

a second current source in communication with a source of another of said pair of cross-coupled MOS transistors;

a frequency dependent gain determining circuit comprising

a first inductor in communication with the drain of said one of said pair of cross-coupled MOS transistors and a first terminal of a voltage source,

a second inductor in communication with the drain of the other of said pair of cross-coupled MOS transistors and the first terminal of the voltage source,

a first capacitor in communication with the drain of said one of said of said pair of cross-coupled MOS transistors and a second terminal of the voltage source, and

a second capacitor in communication with the drain of the other of said pair of cross-coupled MOS transistors and the second terminal of the voltage source; and

an attenuating circuit in communication with said frequency dependent amplifier to reduce the gain of signals having frequencies less than the fundamental frequency to decrease the phase noise, wherein said attenuating circuit comprises a third capacitor in communication with said first and second current sources,

wherein said first current source comprises a first programmable resistance, and wherein said second current source comprises a second programmable resistance.

67. The LC oscillator of the claim 10, wherein said first current source comprises a first programmable inductance, and wherein said second current source comprises a second programmable inductance.